J. Jpn. Bot. **87**: 320–325 (2012)

New or Noteworthy Species of *Graphidaceae* (*Ostropales*, *Ascomycota*) in Korea

Kwang Hee MOON [a], Minoru NAKANISHI [b] and Hiroyuki KASHIWADANI [c, *]

[a] Biological Resources Research Department, National Institute of Biological Resources,
Gyoungser-dong, Seo-gu, Incheon, 404-708 KOREA;
[b] Faculty of Education, Hiroshima University,
1-1-1, Kagamiyama, Higashihiroshima, 739-8524 JAPAN;
[c] Department of Botany, the National Museum of Nature and Science,
4-1-1 Amakubo, Tsukuba, 305-0005 JAPAN
* Corresponding author: kamalina@jcom.home.ne.jp, hk9674@hotmail.co.jp

(Accepted on May 12, 2012)

Four species, *Graphis aperiens* Müll. Arg., *G. jejuensis* K. H. Moon, M. Nakan. & Kashiw., *G. tsunodae* Zahlbr. and *Phaeographis asteriformis* (Zahlbr.) M. Nakan., in the lichen family *Graphidaceae* are reported from Korea. Among them, *Graphis jejuensis* is new to science. It is distinct from allied species of *Graphis* in having short and simple lirellae without striation, erumpent lirellae, open discs without pruina, apically carbonized exciples, inspersed hymenia, colorless spores with 7–8 transverse septa and 18–25 × 7–8 μm in size and in producing no chemical substance. *G. aperiens*, *G. tsunodae* and *Phaeographis asteriformis* are new additions to the lichen flora of Korea.

Key words: *Graphis aperiens, Graphis jejuensis, Graphis tsunodae, Graphidaceae*, lichen, *Phaeographis asteriformis.*

The family *Graphidaceae* is a well-known crustose lichen with lirellate ascomata, including 19 accepted genera (Staiger 2002, Lücking 2009, Lücking et al. 2009). It is also one of the most common crustose lichens found in the Korean Peninsula. In Korea, however, only eight species in two genera have been reported in regional floristic studies; *Graphis anfractuosa* (Eschw.) Eschw., *G. cervina* Müll. Arg., *G. handelii* Zahlbr., *G. intricata* Fée, *G. proserpens* Vain., *G. rikuzensis* (Vain.) M. Nakan., *G. scripta* (L.) Ach. and *Sarcographa tricosa* (Ach.) Müll. Arg. (Huneck et al. 1989, Ka et al. 1997, Kim 1979 and 1981, Moon 1999, Joshi et al. 2009).

Recently Moon and Kashiwadani found a well-developed colony of *Graphis* in Jeju Island (= Cheju Island), located SW of the Korean Peninsula. In the present paper, the lichen will be described as new to science, under the name *G. jejuensis* K. H. Moon, M. Nakan. & Kashiw. In addition, *G. aperiens* Müll. Arg., G. *tsunodae* Zahlbr. and *Phaeographis asteriformis* (Zahlbr.) M. Nakan. are newly reported from Korea.

Materials and Methods

The present study is based on specimens of the family Graphidaceae collected from 2007 to 2010 by Kashiwadani and Moon in Jeju Island

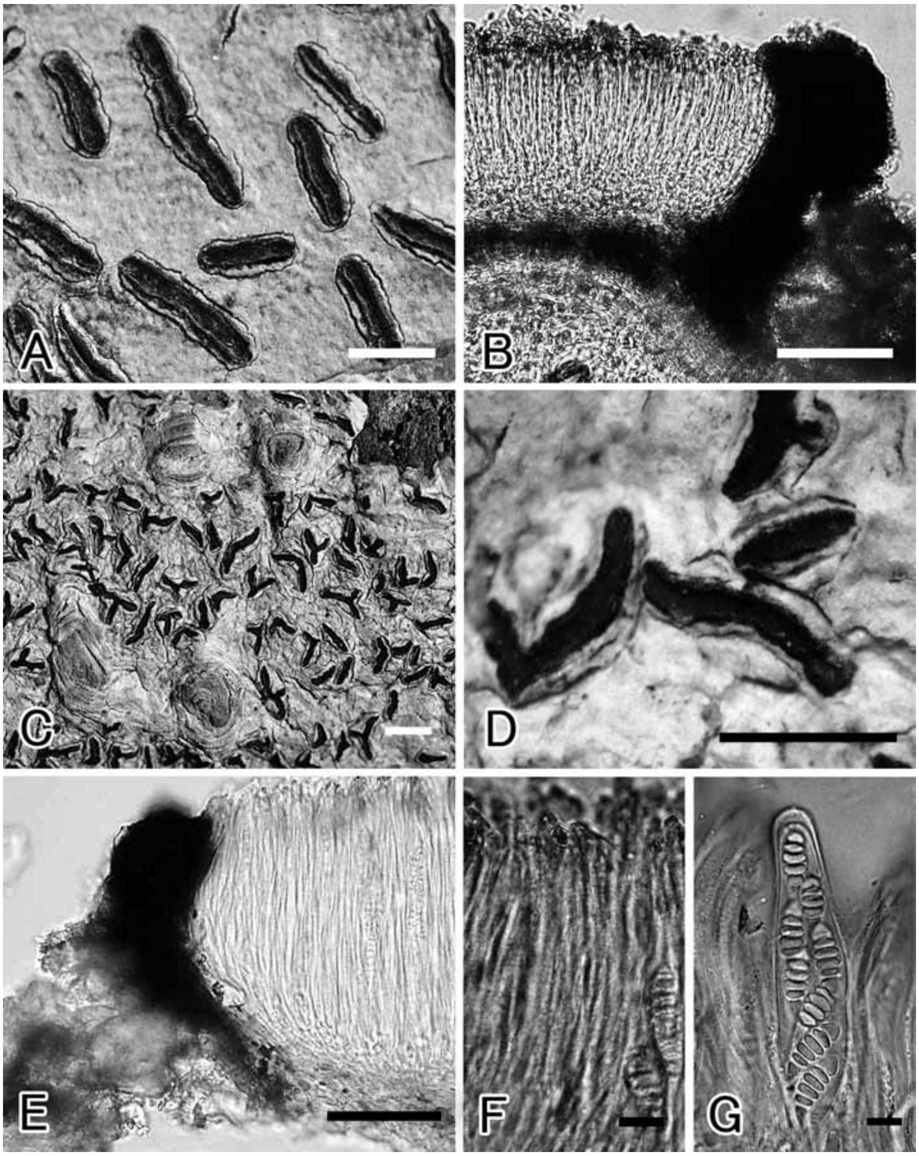

Fig. 1. A–B. *Graphis aperiens* Müll. Arg. (K. H. Moon 20024, NIBR). A. Habit. B. Cross section of an apothecium, showing carbonized exciple laterally and basally. C–G. *G. jejuensis* K. H. Moon, M. Nakan. & Kashiw. (K. H. Moon 11408, NIBR–holotype). C. Habit. D. Close-up of apothecia, showing simple or weakly branched lirellae with open discs. E. Cross section of an apothecium, showing laterally carbonized exciple on the upper half. F. Inspersed hymenium. G. Spores with transverse septa. Scale bars = 1 mm (A, C, D), 50 μm (B), 30 μm (E) and 10 μm (F, G).

and Mt. Juwang, Prov. Gyungsangbuk-do, Korea. Specimens reported in the present paper are kept in the Herbarium, National Institute of Biological Resources (NIBR) unless otherwise cited. Chemical substances were studied by means of thin-layer chromatography (Culberson and Johnson 1982). Sections of apothecia and thalli were cut by hand-razor and mounted in GAW solution.

Taxonomic treatment

Graphis aperiens Müll. Arg., Flora **74**:113 (1891). [Figs. 1A, B]

The characteristic features for *Graphis aperiens* are the brownish gray to grayish green thallus, erumpent lirellae without striations, open disc with white pruina (Fig. 1A), completely carbonized exciples which are often thin but closed basally (Fig. 1B), inspersed hymenium, colorless spores with 7–11 transverse septa, 21–32(–45) × 7–8 μm in size and the presence of norstictic acid as a major chemical substance.

Graphis aperiens was described from Japan [Type collection: Tokyo, 1890, M. Miyoshi s.n.–holotype G !]. Specimens from Korea are coincide well with the type morphologically and chemically. *Graphis aperiens* might be confused with *G. handelii* Zahlbr., a species commonly found in eastern Asia, because they both have similar lirellae with open discs and in producing norstictic acid. However, *G. handelii* differs in having epruinose discs and proper exciples carbonized laterally. It also resembles *G. assimilis* Nyl., a species widely distributed in eastern Asia, which differs in having clear hymenium without inspersion and by the absence of pruina on the discs.

This species is widely distributed in tropical and subtropical regions in the world, having been reported from Australia, China, India and Indonesia and Japan (Lücking et al. 2009, Nakanishi 1966). In the present area, it is not so common but recently collected by Moon in Mt. Juwang where it grows on bark of *Carpinus* sp. Therefore, the distribution of *G. assimilis* now extends to Korea.

Specimen examined: KOREA. Prov. Gyungsangbuk-do: near the Jusodae rock, Mt. Juwang, Sanghuhi-ri, Budon-myoun, Chongsong-gun. On bark of *Carpinus* sp, elevation about 250 m, 28 February 2010, K. H. Moon 20024 (NIBR).

Graphis jejuensis K. H. Moon, M. Nakan. & Kashiw., sp. nov. [Figs. 1C–G]

Similis *Graphi oligospora* sed discis apertis et hymeniis inspersis differt.

Thallus corticolous, whitish gray, continuous, smooth. Apothecia short, simple to very sparsely branched, up to 1.6 mm long, 0.24–0.3 mm wide; lirellae erumpent, covered with thalline margins nearly up to the top; labia entire, without striation; discs open, dark reddish brown, epruinose; exciples carbonized apically or at the upper half, 25–28 μm thick near the top, 10–12 μm thick at side; hymenium inspersed, 100–105 μm high, I + blue; hypothecium 10–15 μm thick. Asci 8-spored; spores colorless (I + purple), 5–8 transversely septate, 20–25 × 7–8 μm in size.

Type collection: **KOREA**. Prov. Jeju: around Kwanum temple, Ara 1 dong, Jeju-shi, on bark of *Daphniphyllum macropodum*, elevation 560 m, 15 May 2007, K. H. Moon 11408 (NIBR–holotype ; TNS–isotype).

Chemistry: No chemical substance detected by TLC.

Graphis jejuensis is unique in having simple to sparsely branched lirellae form apothecia, erumpent labia without striation (Fig. 1C and 1D), open discs without pruina (Fig. 1D), exciples carbonized apically to upper half (Fig. 1E), inspersed hymenia (Fig. 1F) of “type A“ shown by Lücking (2009), transversely 6–8-septate colorless spores (Fig. 1G) and in producing no chemical substance.

Graphis jejuensis resembles *G. oligospora* Zahlbr., a species described from China [Type collection: CHINA, Setschwan (Sichuan), N of Yenyuen, 2325 m, May, 21, 1914, Handel-Mazettii 2451, W–holotype !], in having similar lirellae with apically carbonized exciples and similar spores. However, it can be distinguished from the latter by the smooth thallus, the open disc and by the inspersed hymenium; the latter species has a rough thallus, closed disc and clear hymenium. It can be confused with *G. rikuzensis* (Vain.) M. Nakan., a species reported from Japan [Type collection: JAPAN, Honshu, Prov. Gamo, on bark, October 18, 1918, T. Tsunoda s.n. (hb. A. Yasuda 250, TUR–Vainio 27814–holotype !; TNS–isotype !], which differs in having well branched lirellae, almost closed discs and clear hymenia.

This species is so far known only from the type locality.

Graphis tsunodae Zahlbr. in Ann. Mycol. **14**: 47 (1916). [Fig. 2A]

The characteristic features for this species are the prominent lirellae, the striate labia, the apically carbonized exciples, the clear hymenia without inspersion, the colorless spores with 7–11 transverse septa and the absence of chemical substances.

Although *Graphis tsunodae* was described by Zahlbruckner (1916) based on a collection made in Japan [Type collection: JAPAN, Honshu, Prov. Kohzuke (Pref. Gunma), Mt. Akagi, on bark, K. Tsunoda 182, W! – holotype], it has never been reported from Korea, though it was included in the worldwide key for the genus *Graphis* by Lücking et al. (2009).

Among species of the *Graphis* in eastern Asia, *G. proserpens* Vain. [Type collection: BRAZIL, Vainio s. n. (TUR-Vainio 27557A, not seen)] and *G. rockii* Redinger [Type collection: CHINA, K. M. Redinger 324, W–holotype !] have similar lirellae with striate lirellae like *G. tsunodae*. Recently, Lücking et al (2009) treated *G. rockii* as a synonym of *G. tsunodae*. In addition, they placed *G. proserpens* and *G. tsunodae* as distinct species, *G. tsunodae* has prominent sessile lirellae which are lacking thalline margins or poorly developed only at the base, whereas *G. proserpens* has the erumpent lirellae with basal to lateral thalline margins (Lücking et al. 2009).

Recent studies of Korean *Graphis* by the authors revealed that specimens listed below have morphological and chemical features found in the holotype specimen of *G. tsunodae* and now identified with this species. Specimens reported from Mt. Sorak under *G. proserpens* by Moon (1999) are also identified with *G. tsunodae*.

In Korea, this species grows on barks of deciduous broad-leaved trees such as *Betula*, *Carpinus, Fraxinus* and *Quercus* at elevations above ca. 500 m.

Specimens examined: KOREA. Prov. Kangwon: En route from Hangyeryong pass to Kudchongbong, Mt. Sorak, Inje-gun, on bark of *Fraxinus mandshurica*, elevation 1000–1300 m, September 9, 1996, K. H. Moon (1640, TNS) & H. Kashiwadani; En route from Bisondae to Yangpogsanjang hut, Mt. Sorak, Sokcho city, on bark of *Quercus serrata*, elevation 300–560 m, July 16, 1996, K. H. Moon (775, TNS) & H. Kashiwadani; En route from Yangpogsanjang hut to Mangyongdae, Mt. Sorak, Sokcho city, on bark of *Quercus crispula,* elevation 560–1000 m, July 16, 1996, K. H. Moon (817, TNS) & H. Kashiwadani. Prov. Jeju: around Kwanum temple, Ara 1 dong, Jeju-shi, on bark of *Carpinus* sp.; elevation 560 m, August 29, 2010, K. H. Moon 11407 (NIBR).

Phaeographis asteriformis (Zahlbr.) M. Nakan. in J. Sci. Hiroshima Univ., Ser. B, Div. 2 (Bot.) **11**: 83 (1966). [Fig. 2B]

Phaeographis asteriformis was described by Zahlbruckner based on a specimen collected in northern Japan [Type collection: Honshu, Prov. Rikuzen (Pref. Miyagi), Sendai, A. Yasuda 146, W–holotype !] and has been well revised taxonomically by Nakanishi (1966). The diagnostic characteristics for this species are; the smooth thallus, the radiately branched lirellae, the erumpent lirellae covered by thallus nearly up to the top, the smooth labia without striations, the open discs with whitish gray pruina, the exciples carbonized apically and basally, the clear hymenia, the 8-spored asci, the brown spores with transversely 6–8 septa, 25–40 × 9 μm in size and the absence of chemical substances.

Although this species is commonly found throughout Japan from Hokkaido to Kyushu, it has never been reported from Korea. However, one specimen collected in Jeju Island was found to have the characteristics and features described above and now identified with *P. asteriformis.* In Jeju, it grows on twigs of *Ilex crenata* at elevation about 1100 m.

Specimens examined: KOREA. Prov. Jeju: 1100 marsh, Mt. Halla, Saeckdal-dong, Serguihpo city (33°22′N, 126°28′E), on bark of *Ilex crenata,* elevation about 1100 m, Aug. 21, 2005, K. H. Moon (no. 8538, NIBR) & H. D. Kim.

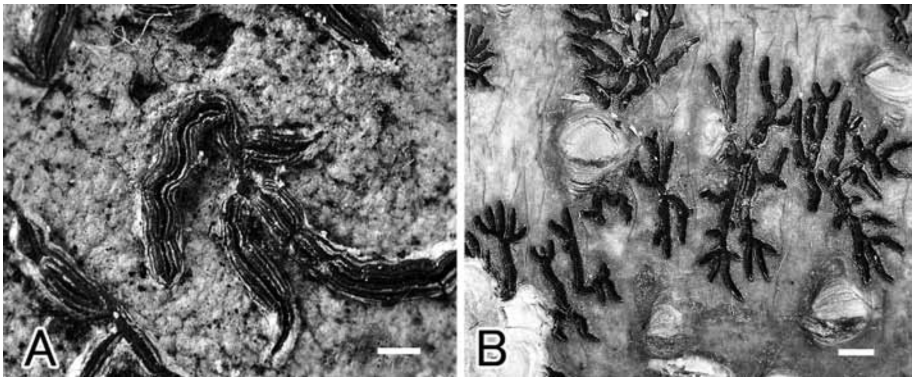

Fig. 2. A. Habit of *Graphis tsunodae* Zahlbr. (K. H. Moon 11407, NIBR). B. Habit of *Phaeographis asteriformis* (Zahlbr.) M. Nakan. (K. H. Moon 8538, NIBR) & H. D. Kim. Scale bars = 0.3 mm (A) and 1 mm (B).

We wish to express our sincere thanks to curators of TUR, US and W for examination of type specimens used for the present study. Thanks are also to Dr. S. Y. Yoon, Hankuk University of Foreign Studies, Seoul for her corrections of our English manuscript.

Literatures Cited

Culberson C. and Johonson A. 1982. Subsitution of methyl ter.-butyl ether for diethyl ether in the standardized thin-layer chromatographic method for lichen products. J. Chrom. **238**: 483–487.

Huneck S., Dza R. J., Ahti T. and Poelt J. 1989. Zur Kenntnis der Flechtenflora von Korea. Herzogia **8**: 177–185.

Joshi Y., Lee Y. M., Wang X. Y., Koh Y. J. and Hur J. S. 2009. New record of existence of *Sarcographa tricosa* (Lichenized *Ascomycota*. *Graphidaceae*) in Korea. Mycobiology **37**: 152–154.

Ka Kang-H., Park, H., and Ryoo Cheon-I. 1997. Lichen flora of Ullung Island (I). *Graphis* and *Pyrenula* genera. Korean J. Mycol. **25**(2): 77–84.

Kim S. H. 1979. Studies on the lichens in Korea. A list of lichens collected in the Mt. Han-ra, with some new addition to the Korea flora. Bull. Kongju Teachers Coll. **15**: 259–268.

Kim S. H. 1981. Flora studies on the lichens in Korea. Bull. Kongju Teachers Coll. **17**: 279–305.

Lücking R. 2009. The taxonomy of the genus *Graphis sensu* Staiger (*Ascomycota*: *Ostropales: Graphidaceae*). The Lichenologist **41**: 319–362.

Lücking R., Archer, A. W. and Aptroot A. 2009. A world-wide key to the genus *Graphis* (*Ostropales: Graphidaceae*). The Lichenologist **41**: 363–452.

Moon K. H. 1999. Lichens of Mt. Sorak in Korea. J. Hattori Bot. Lab. **86**:187–220.

Nakanishi M. 1966. Taxonomical studies on the family *Graphidaceae* of Japan. J. Sci. Hiroshima Univ., Ser. B, Div. 2 (Bot.) **11**: 51–126.

Staiger B. 2002. Die Flechtenfamilie *Graphidaceae*, Studien in Richtung einer natürlicheren Gliederung. Bibl. Lichenol. 85: 1–526.

Redinger K. M. 1934. *In*: Zahlbrucker A. and Redinger, K. M., Shadae, Lich. Rar. Exs. No. 324.

Zahlbruckner A. 1916. Neue Flechten VIII. Ann. Mycol. **14**: 45–61.

Zahlbruckner A. 1934. Nachträge zur Flechtenflora Chinas. Hedwigia **74**: 195–213.

文　光喜[a], 中西　稔[b], 柏谷博之[c]: **韓国産モジゴケ科（子嚢菌門，ビンタケ目）の新種及び注目種**

韓国産モジゴケ科の分類学的研討を行ったので報告する．韓国ではモジゴケ科地衣類は低地から亜高山にかけて広く分布する痂状（固着）地衣類の一つである．韓国産のモジゴケ科はこれまでに *Graphis anfractuosa* (Eschw.) Eschw., *G. cervina* Müll. Arg., *G. handelii* Zahlbr., *G. intricata* Fée, *G. proserpens* Vain., *G. rikuzensis*

(Vain.) M.Nakan., *G. scripta* (L.) Ach., *Sarcographa tricosa* (Ach.) Müll.Arg. の2属8種が報告されているが，筆者等の最近の研究によって，新たに *Graphis aperiens* Müll. Arg., *G. jejuensis* K. H. Moon, M. Nakan. & Kashiw., *G. tsunodae* Zahlbr., *Phaeographis asteriformis* (Zahlbr.) M. Nakan. の3種が確認されたので報告する．このうち，*G. jejuensis* は済州島で発見された新種である．また，*G. proserpens* の名でかつて韓国から報告された標本は *G. tsunodae* と同定された．以下，各種について概略を述べる．

1) *Graphis aperiens* Müll. Arg.：地衣体は淡灰褐色で平滑，リレラは単一またはわずかに分枝する．果托は上部近くまで薄い地衣体に被われるが線状痕はない．盤は灰白色の粉霜を生じる．果殻は側面，底部共に炭化するが，底部の炭化部は薄い．側糸は Lücking (2009) が指摘した “type A” 型の微細な油滴状物質を含む．子嚢は8個の胞子を生じる．胞子は無色，長楕円形で7–11本の横隔膜のみを持つ , 21–32(–45) × 7–8 µm．地衣成分はノルスチクチン酸である．本種は子器の外観やノルスチクチン酸を含む *G. handelii* に似ているが，後者は盤に粉霜はなく，果殻は側面のみが炭化することで区別できる．韓国新産.

2) *Graphis jejuensis* K. H. Moon, M. Nakan. & Kashiw.: 地衣体は灰白色，粉芽や裂芽はない．リレラは短く，単一または僅かに分枝する．果托は上部まで地衣体で被われるが線状痕はない．盤は開き，黒褐色で光沢があり粉霜は生じない．果殻は側面の上半分のみ炭化し，底部は炭化しない．側糸は “type A” 型の油滴状物質を含む．子嚢は8個の胞子を生じる．胞子は，長楕円形で5–8本の横隔膜のみを持つ , 20–25 × 7–8 µm. 地衣成分は含まない．本種は北半球に広く分布する *G. tenella* Ach.，中国産の *G. oligospora* Vain.，日本産の *G. rikuzensis* に似ている．しかし，*G. tenella* とは，果托に線状痕がなく果殻は上部のみ炭化し，側糸に油滴状物質を含む点で区別できる．また，*G. oligospora* や *G. rikuzensis* は盤が閉じ，側糸には油滴状物質を含まないことで異なる．本種は木漏れ日があたるユズリハの樹皮上に着生していた．これまでの調査では基準種が採集された場所以外では発見されていない．韓国特産.

3) *Graphis tsunodae* Zahlbr.: 本種は群馬県赤城山の標本をタイプとして記載された種である．リレラは地衣体から明瞭に盛り上がり，果托の頂部近くまで薄く地衣体で被われるが，明瞭な線状痕を持つので近縁種からは容易に区別できる．東アジアではリレラに明瞭な線状痕を持つ種として，本種の他に *Graphis proserpens* と *G. rockii* Redinger が報告されている．Lücking ら (2009) は *Graphis tsunodae* を *G. rockii* のシノニムとして扱っている．筆者等のタイプに基づく観察によると，*G. tsunodae* は線状痕が2–8本と少なく，リレラは上部まで薄く地衣体に被われるのに対し，*G. rockii* のリレラは地衣体上に突出し12–17本の密な線状痕が発達して完全に裸出し，地衣体はリレラの下部を被うだけである．これらの特徴から，筆者等は *G. tsunodae* を独立種として扱うことを提唱する．なお，*Graphis proserpens* との関連連については，その基準標本を検討する機会がなかったので両種の関連性の検討を保留する．

4) *Phaeographis asteriformis* (Zahlbr.) M. Nakan.：本種は宮城県仙台市の標本を基に Zahlbruckner (1916) が *Graphis asteriformis* Zahlbr. の名で記載したものであり，分類学的な検討はすでによくなされている (Nakanishi 1966)．本種はリレラが放射状に分枝し，盤は凸状で薄い粉霜を生じ，胞子は褐色で5–8本の横隔膜を持ち，地衣成分を含まない特徴などで近縁種から容易に区別できる．近隣の日本列島では北海道から九州に至る広い範囲に分布するが，韓国では現在のところ済州島産の標本が唯一の記録である．

([a] 韓国・国立生物資源館生物資源研究部,
[b] 広島大学教育学部,
[c] 国立科学博物館植物研究部)